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54 Ultrafiltering hybrid artificial organ.

57 An artificial hybrid organ or gland is formed from two serially-interconnected chamber (12)(14), the first of which (12) comprises an ultrafiltration chamber which forms an ultrafiltrate from the blood stream applied to it and the second of which (14) comprises a cell exchange chamber which, though immunologically isolated by microporous membranes (16)(18), receives both the bloodstream and the ultrafiltrate and which rapidly exchanges selected constituents with both before they recombine, in order to provide a corrected physiological response to constituents in the blood. Additionally, an optional excretory duct (104) may be employed to channel a portion of the treated ultrafiltrate away from the bloodstream.

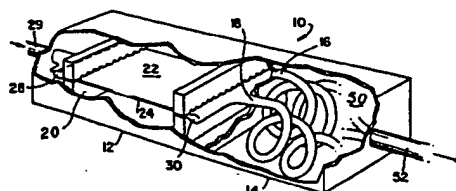


Fig 1

ULTRAFILTERING HYBRID ARTIFICIAL ORGAN

Background of the Invention1 A. Field of the Invention

2 The invention relates to artificial organs and
3 glands and comprises an ultra filtering hybrid
4 artificial organ or gland for providing a corrected
5 physiological response to blood constituents in a
6 rapid manner.

7 B. Prior Art

8 Increased activity in recent years has been
9 devoted to developing artificial organs of various
10 kinds. Much of the early effort has been devoted to
11 developing organs which perform primarily mechanical
12 functions, e.g., the heart. More recent activity has
13 extended to the construction of organs which attempt
14 to duplicate body physiology, e.g., dialysis devices
15 and the like. This typically presents a more
16 difficult problem than duplication of mechanical
17 functions, due to the complexities of the physiologic
18 system. An even greater level of difficulty is
19 presented in the design and construction of devices
20 which duplicate glandular functions, and progress in
21 this area has been less rapid than in others.

22 Several devices which perform the function of
23 the endocrine pancreas have been proposed. Aside from
24 wholly artificial devices that depend on glucose
25 sensors, algorithmic controllers, and refillable
26 insulin reservoirs, attempts have been made to utilize
27 natural pancreatic beta cells within an artificial
28 structure as a form of protected and facilitated
29 transplantation known as a hybrid artificial pancreas.
30 Such devices include mechanisms for closely contacting

1 the blood of a patient with this living glandular
2 material, usually through a microporous membrane
3 separating the two, so that the glandular material may
4 respond to various constituents in the blood and
5 exchange selected material therewith by simple
6 diffusion, yet avoid rejection by host lymphocytes and
7 antibodies that are too large to pass through the
8 pores. In these devices, the glandular material
9 actually adheres to the membranes and grows into and
10 encroaches the pores resulting in proximity to the
11 blood compartment improving diffusion back and forth
12 across the membrane.

13 Such devices constitute an advance in the art
14 but suffer the critical disadvantage, among others,
15 that there is a significant time delay in the process
16 of diffusion of various constituents, such as glucose
17 and insulin, across the membrane despite the use of
18 large membrane surface areas. This delay is
19 undesirable to the extent that it departs from the
20 normal tight physiological control and, in some cases,
21 may present a risk to an individual dependent on such
22 a device for rapid response to abnormal body
23 conditions, i.e., a stressed diabetic relying on the
24 device for production of insulin in response to
25 acutely changing glucose levels in the blood.
26 Additionally, this loose control of blood sugar may
27 prevent the long-term tight control of diabetes
28 necessary to prevent the complications of retinopathy
29 and nephropathy, neuropathy, and accelerated vascular
30 disease that all too often results in blindness,
31 kidney failure, impotence, and premature heart attack.

32
33 Summary of the Invention

34 A. Objects of the Invention

1 Accordingly, it is an object of the invention
2 to provide an improved hybrid artificial organ or
3 gland.

4 Further, it is an object of the invention to
5 provide an improved hybrid artificial gland.

6 Specifically, it is an object of the invention
7 to provide a hybrid artificial pancreas, liver, or
8 kidney, providing an improved response to body
9 stimuli.

10

11 B. Brief Description of the Invention

12 For purposes of illustration, the present
13 invention will be described primarily in terms of an
14 artificial gland and, more specifically, a hybrid
15 artificial pancreas. However, it should be understood
16 that the device of the present invention is also
17 particularly well adapted to function as an artificial
18 non-glandular organ as well (e.g., liver and kidney),
19 with certain modifications that will be described
20 later, as well as an endocrine gland in general. In
21 accordance with the preferred embodiment of the
22 present invention, I provide an ultra filtering hybrid
23 artificial pancreas formed from two treatment stations
24 in series, the first of which forms an ultrafiltrate
25 through a microporous membrane from preferably
26 arterial blood supplied to it, and the second of which
27 contains a cellular exchange medium, such as beta
28 cells, which respond to both the ultrafiltrate and to
29 the whole blood for necessary oxygenation, to provide
30 the desired physiologic response to constituents in
31 the ultrafiltrate and in the blood. The ultrafiltrate
32 and the blood, now carrying the response
33 constituent(s) of the cellular exchange medium
34 (insulin), are then recombined, either by direct

1 mixing or by re-absorption of the ultrafiltrate into
2 the bloodstream via a microporous membrane, and the
3 blood returned to the body system.

4 Ultrafiltration (as contrasted with simple
5 diffusion) relies on a hydrostatic pressure gradient
6 across a membrane (instead of a concentration
7 gradient); this results in large numbers of molecules
8 "streaming" unidirectionally through pores in unison
9 (rather than moving bidirectionally as in simple
10 diffusion). This phenomenon of ultrafiltration is
11 referred to technically as "convective mass transfer"
12 or "solute drag", since adjacent molecules drag each
13 other across the membrane; in consequence, molecules
14 such as glucose for example, are washed across the
15 ultrafiltration membrane much more rapidly than would
16 be the case with simple diffusion. Consequently the
17 surface area of the ultrafiltering membranes may be
18 significantly reduced as compared to diffusion
19 membranes in previous devices, thereby allowing more
20 favorable design alternatives.

21 The resulting component of ultrafiltrate is
22 generally quite similar to that of the fluid
23 compartment of whole blood from which it is derived
24 except for a depressed calcium level, and the absence
25 of proteins and cells. Specifically, the
26 concentration of glucose in the ultrafiltrate closely
27 tracks the level of glucose in the blood from which it
28 is derived at any given time. Thus, the response of
29 beta cells to the ultrafiltrate is very close to the
30 normal physiological response of these cells in a
31 nondiabetic individual. Moreover, the glucose-insulin
32 exchange across a semipermeable membrane with beta
33 cells on one side and ultrafiltrate on the other is
34 significantly faster than that across a corresponding

1 membrane having beta cells on one side and whole blood
2 on the other side, where proteins and blood cells
3 interfere with transfer through the membrane pores.
4 Thus, the device of the present invention provides a
5 significantly faster physiological response than one
6 in which the exchange takes place by simple diffusion
7 with whole blood only. However, it also provides
8 immunologically protected contact, through a
9 microporous semipermeable membrane, between the beta
10 cells and whole blood which contains oxygenated red
11 blood cells in order to maintain the continued
12 viability of the beta cells.

13 In the preferred embodiment of the invention,
14 the exchange station comprises a chamber having first
15 and second tubular membrane coils formed therein for
16 transporting ultrafiltrate and blood, respectively,
17 through the device. The chamber is filled with
18 glandular or organ materials such as beta cells which,
19 in response to glucose or other constituents in the
20 ultrafiltrate and/or in the blood, release insulin
21 which crosses the respective membranes to the
22 ultrafiltrate and to the blood. The ultrafiltrate and
23 the blood are then recombined, after their exposure to
24 the beta cells, for subsequent utilization by the
25 body. In this embodiment, the membrane separating the
26 ultrafiltrate from the exchange cells may
27 advantageously have a significantly larger pore size
28 than that separating the blood stream from the cells,
29 since the ultrafiltrate is free of adverse
30 immunological agents such as cells and antibodies
31 which might otherwise attack the exchange cells. A
32 larger pore size provides more rapid transfer of
33 insulin to the ultrafiltrate and thus, ultimately, to
34 the patient's bloodstream.

1 In another embodiment of the invention, the
2 ultrafiltrate is supplied directly to the exchange
3 chamber where it comes in direct contact with the beta
4 cells for ultrarapid stimulation of insulin
5 production. The ultrafiltrate is then re-absorbed
6 through the pores of the membrane separating the
7 bloodstream from the exchange medium and it is then
8 returned to the body together with the blood. In
9 cases where the reabsorption rate of this system would
10 be inadequate, due to the particular flow rates or
11 membranes used, or due to other such factors,
12 provision may be made for directly draining a portion
13 of the insulin-containing ultrafiltrate from the
14 cellular exchange portion by a mechanical bypass which
15 reunites it with the bloodstream. This alternative
16 results in yet another unique feature of the device,
17 that of transporting insulin directly to the
18 bloodstream, instead of relying on the much slower
19 diffusion of insulin across microporous membranes as
20 in previous devices. This results in a shorter, more
21 nearly "correct" physiological response time, and
22 compensates for the slower diffusion rate of insulin
23 compared to glucose, since the diffusion rate is a
24 function of molecular weight rather than solute size
25 as in ultrafiltration. A microporous membrane of much
26 greater pore size than that of the membrane carrying
27 the blood through the exchange channel may be
28 interposed in the drain to prevent loss of cells from
29 the exchange chamber while allowing rapid passage of
30 insulin with the ultrafiltrate. Due to the tendency
31 of beta cells to aggregate and clump on membrane
32 walls, and thus anchor themselves to it, it is
33 possible that even the drain membrane may be dispensed
34 with, with only slight loss of beta cells.

1 The ratio of ultrafiltrate flow to blood flow
2 directly affects the response characteristics of the
3 device. The greater the ultrafiltrate flow in
4 relation to the blood flow, the more rapidly the
5 device responds to physiologic changes in the
6 bloodstream. However, when the device is used as a
7 hybrid organ, where a portion of the ultrafiltrate may
8 result in an excretory product (e.g., bile or urine),
9 too great a ratio of ultrafiltrate flow to blood flow
10 could result in adverse physiological effects (e.g.
11 dehydration). This ratio may be controlled by varying
12 the hydrostatic pressure in the ultrafiltration
13 portion, as well as by appropriate selection of the
14 ultrafiltration membrane area and configuration, the
15 diffusion membrane area and configuration, membrane
16 thickness, pore size, transfer coefficients, and
17 support design, especially the size and configuration
18 of the transport tubes for the blood and the
19 ultrafiltrate. Additionally, this ratio can be
20 controlled by bypassing portions of the blood flow
21 around the ultrafiltration station or around the
22 cellular exchange portion, or by bypassing portions of
23 the ultrafiltrate flow around the cellular exchange
24 station. Various embodiments effectuating these flow
25 patterns are described herein.

26 When used as a hybrid artificial organ, a
27 channel may be formed to drain a portion of the
28 treated ultrafiltrate away from the bloodstream, to
29 thereby remove, for example, waste products such as
30 urine or bile when the device is utilized as an
31 artificial kidney or liver.

1 The foregoing and other and further objects,
2 features, and advantages of the present invention will
3 be understood more readily on reference to the
4 following detailed description of the invention, when
5 take in conjunction with the accompanying drawings in
6 which:

7 Fig. 1 is a view in perspective, with portions
8 cut away, of a preferred embodiment of the invention
9 showing the serially-connected ultrafiltration and
10 cellular chambers;

11 Fig. 2 is a diagrammatic view of an
12 alternative form of the invention in which the
13 ultrafiltrate is brought into direct contact with the
14 beta cells;

15 Fig. 2A is a diagrammatic view of an
16 alternative form of the invention illustrated in Fig.
17 2 showing the provision of an auxiliary shunt for
18 expedited recombination of the treated ultrafiltrate
19 and the whole blood component;

20 Figs. 3A, 3B, and 3C are diagrammatic
21 illustrations of still further alternative embodiments
22 of the invention showing additional techniques for
23 controlling the ratio of ultrafiltrate flow to whole
24 blood flow; and

25 Fig. 4 is a diagrammatic illustration of an
26 artificial organ in accordance with my invention.

27 In Fig. 1, an artificial gland 10 in
28 accordance with the invention is formed from an
29 ultrafiltration chamber 12 serially connected to a
30 cellular exchange chamber 14 by means of tubular flow
31 paths 16, 18. The ultrafiltration chamber may take
32 any of a number of forms commonly used in the medical
33 field. For purposes of illustration, the chamber is
34 shown as comprising a generally rectangular enclosure

1 20 having upper and lower membranes 22 and 24,
2 respectively, closely spaced apart from each other and
3 supported by clamping structures 26 at opposite ends.
4 The membranes open outwardly at their ends into
5 manifolds 28, 30, respectively. A tubular cannula 29,
6 which is preferably connected to the artery of a human
7 or animal body, receives blood from the body and
8 carries it to the manifold 28. After passage through
9 the narrow channel between the membranes 22, 24, the
10 blood accumulates in manifold 30 and thereafter passes
11 into the cellular exchange chamber 14 via conduit 18.

12 During its passage between the membranes,
13 liquid constituents of the blood are forced outwardly
14 through the one or both of the membranes to form an
15 ultrafiltrate which collects within the interior of
16 chamber 20. The ultrafiltrate is then drawn off into
17 chamber 14 via conduit 16. Effectively, the reduced
18 cross-sectional flow area between the membranes
19 provides the requisite back pressure to support
20 ultrafiltration action, while the source of blood
21 provides the requisite positive pressure to do so.

22 Tubular conduits 16 and 18 continue as
23 separate conduits within cellular exchange chamber 14
24 for separate exposure to an exchange medium 50 within the
25 chamber. For purposes of illustration, chamber 14 is
26 shown as a generally rectangular hollow chamber. The
27 conduits themselves are formed from microporous
28 semipermeable membranes whose pore size and wall
29 thickness are such as to allow the transport of
30 selected products across them, while effectively
31 containing the fluid streams within them. For
32 purposes of providing an artificial pancreas, the
33 medium 50 comprises pancreatic beta cells which provide
34 a source of insulin in response to appropriate

1 physiologic signals from the ultrafiltrate and the
2 blood, respectively. Glucose and oxygen contained
3 within the ultrafiltrate within conduit 16 permeate
4 through the membraneous pores of this conduit into the
5 medium 50 within the chamber 14, while insulin
6 permeates through the pores in the reverse direction
7 from the cellular medium 50 into the interior of the
8 conduit 16 where it mixes with the insulin-containing
9 ultrafiltrate within this conduit and is carried off
10 with it. In like fashion, glucose and insulin are
11 exchanged across the membraneous pores of conduit 18
12 between the blood within the conduit and the cellular
13 exchange medium exterior to the conduit. Importantly,
14 oxygen and other nutrients are transported across the
15 pores of conduit 18 into the cellular medium 50 in
16 order to sustain the beta cells. The conduits 16 and
17 18 are rejoined into a single conduit 52 at a
18 transition junction 54. Conduit 52 returns the
19 treated blood to the body, such as by connection into
20 a vein.

21 The operation of the device of Fig. 1 is as
22 follows: Arterial blood diverted from the body to be
23 treated flows through tubular conduit 29 into
24 ultrafiltration chamber 12 where it is separated into
25 an ultrafiltrate component of essentially similar
26 composition to the blood fluid, but lacking in
27 proteins and blood cells, and a blood component
28 containing these constituents. The ultrafiltration
29 portion preferably provides a constricted path for the
30 blood flowing into it in order to build up a suitable
31 pressure to efficiently perform the ultrafiltration.
32 It is expected that in most cases the human or animal
33 body will provide sufficient pressure to support the
34 requisite ultrafiltration portion pressure while

1 continuing fluid blood flow through the device. Where
2 this is not the case, it may be necessary to
3 supplement the body-generated pressure by means of an
4 auxilliary pumping device creating either a positive
5 pressure on the inlet side (i.e., the side adjacent
6 conduit 29) or creating a negative pressure on the
7 outlet side (i.e., the side adjacent conduit 52). In
8 either event, the resultant ultrafiltrate and whole
9 blood component are passed along to the cell exchange
10 chamber 14 via conduits 16 and 18, respectively, where
11 they receive insulin through the tubular membraneous
12 wall from the medium 50. On recombining in conduit
13 52, the insulin-containing ultrafiltrate and blood
14 carry this insulin back to the body for utilization by
15 it in controlling the glucose levels within the blood.

16 Turning now to Fig. 2, a first alternative
17 embodiment in accordance with the present invention
18 has the ultrafiltration chamber 12 serially connected
19 to a cellular exchange chamber 14 as in Fig. 1. A
20 conduit 70 carries ultrafiltrate from the
21 ultrafiltration chamber to the cell chamber, while a
22 conduit 18 carries the remaining whole blood component
23 from chamber 12 to chamber 14. However, in contrast
24 to Fig. 1, the conduit 70 does not continue into the
25 chamber 14 in the form of a tubular semipermeable
26 membrane as in Fig. 1 but, instead, discharges its
27 contents directly into the cellular portion 50 for
28 direct contact with the cellular exchange material
29 (i.e., beta cells) therein. Also, as in the
30 embodiment of Fig. 1, an inlet conduit 29 carries
31 blood from the body, preferably from a high pressure
32 location thereof such as an artery, and a conduit 72
33 carries the treated blood back to the body, preferably
34 to a low pressure location thereof such as a vein.

1 Again, however, unlike the embodiment of Fig. 1, the
2 conduit 72 is continuous only with the conduit 18, and
3 not with the conduit 70 as well. Thus, there is no
4 direct connection between conduit 70 and conduit 72,
5 in contrast to the embodiment of Fig. 1. Instead, the
6 ultrafiltrate material supplied to the interior of
7 chamber 14 obtains access to the conduit 72 only
8 through diffusion through the semipermeable membrane
9 pores of conduit 18. This diffusion is aided by the
10 osmotic pressure difference between the pressure of
11 the insulin-containing ultrafiltrate in chamber 14 and
12 the reduced pressure of the blood component in conduit
13 18; the latter is at a lower hydrostatic pressure
14 while maintaining colloid osmotic pressure. This
15 results in a net fluid and solute flow from the
16 insulin containing ultrafiltrate into the blood
17 conduit according to the well-known principles of the
18 Starling equilibrium of capillary exchange.

19 In another embodiment, the cells in the
20 cellular exchange portion are microencapsulated in a
21 microporous material (membrane) which prevents them
22 from growing into the pores of the other microporous
23 membranes. In this embodiment ultrafiltrate and blood
24 may (optionally) directly mix together in the cellular
25 exchange chamber.

26 Where the ultrafiltrate return rate to conduit
27 72 in Fig. 2 is insufficient to reach equilibrium
28 under steady-state conditions, the filtration rate of
29 ultrafiltrate into the conduit 72 may be increased by
30 further decreasing the pressure in conduit 70 by means
31 of a pump connected to this conduit. Alternatively, a
32 bypass conduit 80 may be connected between chamber 14
33 and conduit 72 to carry additional ultrafiltrate (Fig. 2A)
34 directly from the chamber into the conduit 72. A

1 semipermeable membrane 82 mounted on
2 the interior walls of chamber 14 provides
3 for passage of the ultrafiltrate from this chamber
4 into conduit 72. A valve 86 allows for adjustment of
5 the ultrafiltrate flow rate so that, under steady-
6 state conditions, the rate at which ultrafiltrate is
7 removed in chamber 12 from the blood being treated is
8 the same as the rate at which the ultrafiltrate is
9 being returned to the conduit 72. The area and
10 configuration of the membrane 82 and, correspondingly,
11 the volume of the inlet chamber 80A, may be adjusted
12 as appropriate to vary the ultrafiltrate return rate
13 to conduit 80, and thus to conduit 72.

14 Turning now to Fig. 3, various alternatives
15 for establishing the desired ultrafiltration flow-to-
16 blood flow ratio are shown. In Fig. 3A, a shunt 90
17 bypasses a portion of blood from conduit 29 prior to
18 its entrance into the ultrafiltration chamber 12.
19 Accordingly, the production of ultrafiltrate is
20 diminished by this arrangement and the ratio of
21 ultrafiltrate to blood is correspondingly diminished.
22 In Fig. 3B, a portion of the blood component exiting
23 from chamber 12 is bypassed around the cell exchange
24 chamber by means of a shunt conduit 92. This
25 arrangement leaves intact the ratio of ultrafiltrate
26 to whole blood established by the geometry of chamber
27 12 and the inlet and outlet pressures and flow rates
28 therein, but varies the amount of blood contacting the
29 exchange cells in chamber 14. Accordingly, its effect
30 is equivalent to that of the increase in the
31 ultrafiltration flow-to-blood flow ratio, although it
32 decreases the total amount of blood exposed to the
33 exchange cells. Finally, in Fig. 3C, a portion of the
34 ultrafiltrate is bypassed around chamber 14 through a

1 conduit 94 containing a valve 96 for controlling the
2 flow in conduit 94, and may be returned to the blood
3 and/or partially drained via an optional excretory
4 duct. This embodiment leaves intact the actual ratio
5 of ultrafiltration flow-to-blood flow generated by the
6 ultrafiltrate chamber 12, but decreases the effective
7 ratio of ultrafiltration flow-to-blood flow since it
8 diminishes the amount of ultrafiltrate exposed to
9 exchange cells in chamber 14.

10 So far I have described the preferred and
11 various alternative embodiments of an artificial gland
12 in accordance with my invention. The invention may
13 also be extended to artificial organs, such as livers
14 and kidneys, among others. As seen in Fig. 4, an
15 artificial liver, for example, comprises a filtration
16 chamber 12 receiving blood to be treated via a conduit
17 29 and applying it, after it has been ultrafiltered,
18 through conduit 18 to a cell exchange chamber 100. A
19 conduit 16 carries the ultrafiltrate to chamber 100.
20 Conduit 18 extends through chamber 100 in the form of
21 a multiply-looped coil formed from a semipermeable
22 membrane retaining protein and other major blood
23 constituents on the inside thereof for flow through
24 the chamber within the conduit and returned to the
25 body or other source through conduit 52 as was
26 previously the case. During passage through chamber
27 100, the ultrafiltered blood exchanges various
28 constituents with liver cells 102 within the chamber.
29 Specifically, oxygen, certain nutrients, and waste
30 products flow from the blood to the liver cells 102
31 within the chamber. These blood products sustain the
32 liver cells, and also stimulate them to produce bile.
33 Excretory products are then returned, via a conduit
34 104, to the urinary bladder or other parts of the

- 1 urinary tract in the case of the kidney, or to the
- 2 intestine, in the case of the liver. Alternatively,
- 3 the conduit may lead to a collection bag outside the
- 4 body.

1 Conclusion

2 From the foregoing, it will be seen that I
3 have provided an improved hybrid artificial organ and
4 gland. The device of the present invention provides
5 an effective substitute for injured or diseased organs
6 or glands more nearly approximating the rapid response
7 of an actual body to acutely changing physiological
8 demand and is expected to be capable of sustained
9 functioning over extended periods of time. Various
10 embodiments provide adjustment of the effective ratio
11 of ultrafiltration flow to blood flow to adjust to
12 differing body demands and an optional excretory
13 channel is provided when appropriate for some organ
14 modes.

15 It should also be understood that the term
16 "pores" is used in a functional sense, in that some
17 membranes without microscopically visible pores are
18 capable of transporting substances by physically
19 solubilizing them within the membrane and delivering
20 them across the membrane. It should be understood
21 that different types of cells may be used together for
22 beneficial effect, e.g., mast cells that produce
23 heparin which prevents clotting may be added to beta
24 cells in the cellular exchange portion. Additionally,
25 the cells may be frozen, grown in culture media,
26 pretreated with chemicals or blood constituents such
27 as antilymphocytic globulin to further aide in
28 immunological protection, or treated in other ways
29 promote their survival and longevity or improve their
30 functional response.

31 It is further understood that the membraneous
32 portions of the device may be employed in various
33 configurations including, but not limited to, flat
34 plates, coils, capillary tubes (woven and unwoven),

- 1 singly, in multiples, and in various preferred
- 2 combinations.

CLAIMS

1. An ultrafiltering hybrid artificial organ or gland, said organ or gland providing a differential response to blood constituents, characterized in that it includes an ultrafiltration chamber (12) for receiving blood from
5 a source (29) and for forming both a blood fraction and an ultrafiltrate therefrom, a cell exchange chamber (14) serially connected to said ultrafiltration chamber for receiving both said blood fraction and said ultrafiltrate and configured to enclose a cellular exchange medium
10 (50) for exchanging selected constituents with both the blood fraction and the ultrafiltrate, and means (52) for returning the treated ultrafiltrate and blood fraction to said source.
2. An ultrafiltering hybrid artificial organ or gland
15 according to claim 1, characterized in that the cell exchange chamber (14) includes a microporous membrane transfer means (16)(18) for transferring the selected constituents via the membrane for carrying out the said exchange.
- 20 3. An ultrafiltering hybrid artificial organ or gland according to claim 1, characterised in that it includes means (52) for directly intermixing said treated ultrafiltrate and said blood fraction.
- 25 4. An ultrafiltering hybrid artificial organ or gland according to claim 1, characterised in that there is provided a first cell-free microporous membrane-enclosed channel (22)(24) for ultrafiltration of blood therethrough, and a second microporous membrane-enclosed channel (16) for the passage of treated ultrafiltrate
30 therethrough, a portion of each second channel (16) being positioned for contact with said cellular exchange

medium (50) within said cell exchange chamber (14).

- 5 5. An ultrafiltering hybrid artificial organ or gland according to claim 1, characterized in that in operation the exchange chamber (14) receives said ultrafiltrate for direct contact with said cellular exchange medium (50) and in that there is provided a first microporous membrane-enclosed channel (18) for the passage of blood therethrough for the exchange of constituents with the medium and the ultrafiltrate via the said membrane.
- 10 6. An ultrafiltering hybrid artificial organ or gland according to claim 1, characterized in that means (90) (92)(94,96) is provided for altering the ratio of ultrafiltrate to blood fraction applied to said cell exchange chamber (14).
- 15 7. An ultrafiltering hybrid artificial organ or gland according to claim 6, characterized in that said means for altering the ratio includes a conduit (90) for shunting a portion of the blood from said source (29) around said ultrafiltration chamber (12) prior to its application to said cell exchange chamber (14).
- 20 8. An ultrafiltering hybrid artificial organ or gland according to claim 6, characterized in that said means for altering the ratio includes a conduit (92) for shunting a portion of the blood fraction from said ultra-
- 25 filtration chamber (12) around said cell exchange chamber (14).
- 30 9. An ultrafiltering hybrid artificial organ or gland according to claim 6, characterized in that said means for altering the ratio includes a conduit (94) and a valve (96) for shunting a portion of the ultrafiltrate around said cell exchange chamber (14).

10. An ultrafiltering hybrid artificial organ according to claim 1, characterized in that there is provided an excretory duct (104) to drain a portion of the treated ultrafiltrate away from the blood stream.

5 11. An ultrafiltering hybrid artificial organ according to claim 6, characterized in that there is provided an excretory conduit (104) to drain a portion of the treated ultrafiltrate away from the blood stream.

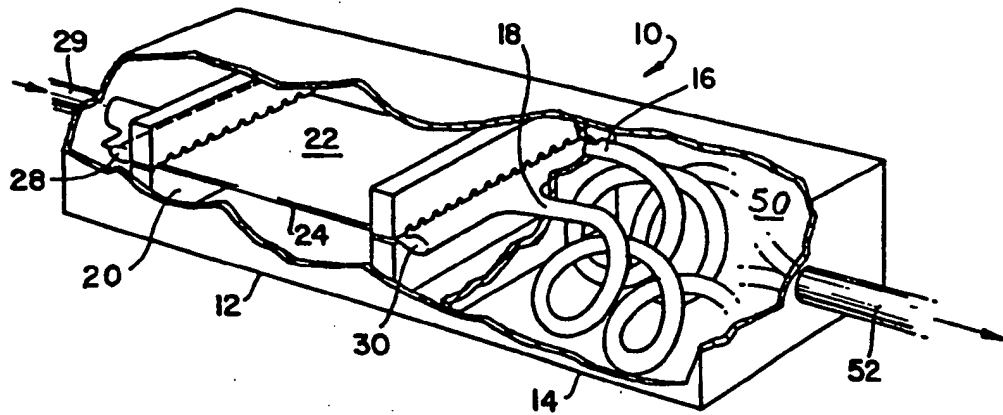


Fig. 1

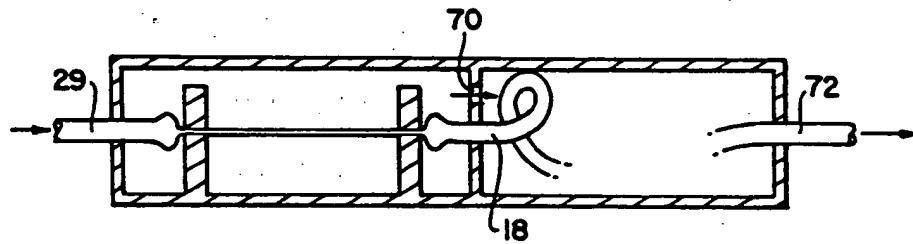


Fig. 2

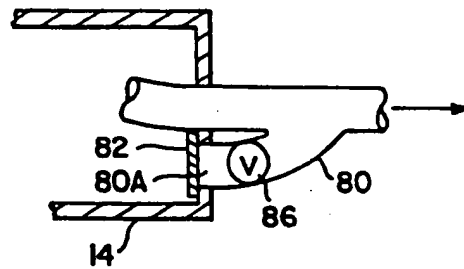
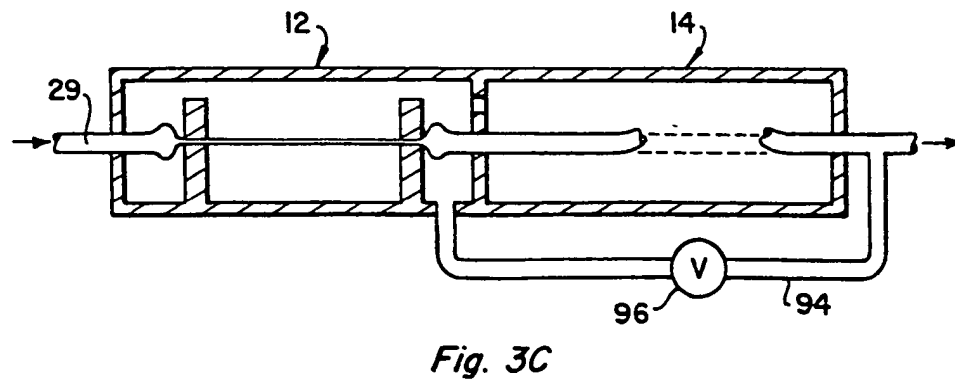
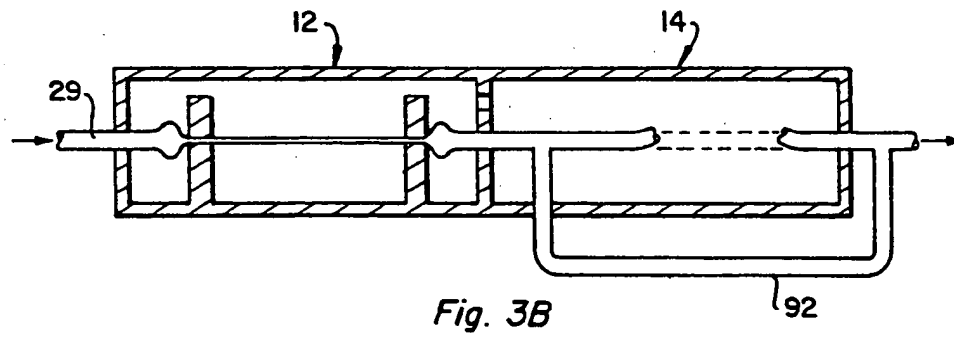
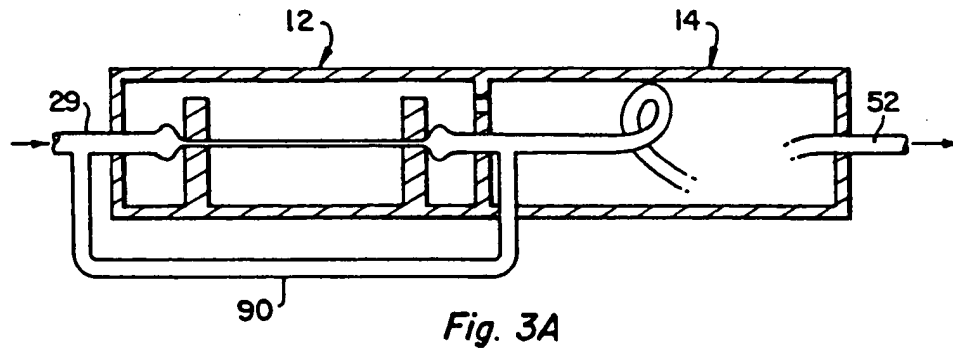
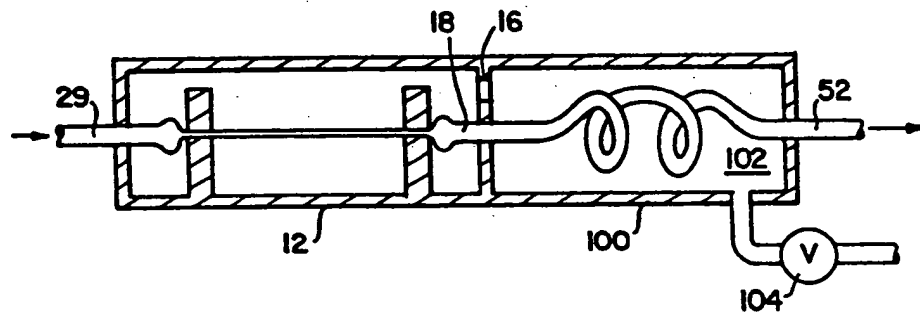


Fig. 2A



*Fig. 4*